(12)

EUROPEAN PATENT APPLICATION

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(54) NUMERICAL CONTROLLER.

(57) A numerical controller which reliably liberates the positional precision from the effect of static friction and dynamic friction applied as disturbance to the servo loop in the case when a servo system is constructed in the form of a semi-closed loop to numerically control a machine tool driven by a servo motor and to determine its position. The numerical controller has a backlash correction function and supplies the servo system with a backlash correction data (BL(I)) that is distinguished from the ordinary motion command (MC(I)). In response to the backlash correction data (BL(I)), an offset command that corresponds to a friction torque Fa in the mechanical system is given to the servo system as a torque correction signal (FR(I)).

EP 0 292 574 A1

DESCRIPTION

NUMERICAL CONTROL APPARATUS

Technical Field

This invention relates to a numerical control
apparatus, which has a backlash correction function for
a move command, for effectively carrying out
positioning in a semi-closed loop servo system.

Background Art

A semi-closed loop-type control circuit of the
kind shown in Fig. 3 is employed as a CNC servo-control
circuit. In the Figure, an information processing
circuit X comprises a CPU and a memory and forms a
command signal for a servomotor. A servomechanism Y is
constituted by a comparator circuit a for comparing the
command signal and a signal from a position detector e,
a servo drive circuit b, a servomotor c, a velocity
detector d and a position detector e employing a
resolver or a pulse encoder, and is adapted to control
a machine Z such as a table via a ball screw shaft f.

As illustrated, the semi-closed loop system
controls a load by performing position detection at a
portion of the motor shaft or ball screw shaft in front
of the machine Z, such as a table, which is the object
to be finally controlled. Control is performed
accurately up to the motor shaft or ball screw shaft,
and from this point onward control depends on the
precision of the machine.

Fig. 4 is a block diagram of such a servo-control

system, in which K denotes position gain, k_1 and k_2 gains, K_T a torque constant, T_L disturbance, and J_m rotor inertia.

5   In control of the machine by such a semi-closed loop system, a response delay due to backlash in the mechanical system arises when there is a change in the direction of servomotor rotation. In order to improve upon this delay with respect to a move command, the conventional practice is to supply the servo system

10   with a backlash correction signal together with the move command signal.

Fig. 2 is a block diagram illustrating an example of a control circuit in which a backlash correction signal BL(i) of this kind is inputted together with a

15   move command signal MC(i) to the servo system to form a torque command. In Fig. 2, an integration term z^{-1} is expressed using a Z conversion (pulse transfer function conversion). VEL(i) indicates a fed back velocity signal, and POS(i) represents an amount of movement in

20   a sampling period T, namely a fed back position signal.

In this conventional control circuit, the response delay of the servo system is improved by inputting the backlash correction signal to the servo system. However, since frictional resistance is present in an

25   actual servomotor and machine, positional displacement based on a response delay still remains when the servomotor reverses its direction of rotation. If a machine tool is to be controlled along, e.g., a

circular arc by controlling a plurality of axes simultaneously, positional displacement caused by frictional resistance in the machine tool will hinder machining along a true circle.

5   Disclosure of the Invention

The present invention has been devised in order to solve the aforementioned problem and its object is to provide a numerical control apparatus capable of improving the positional precision in a semi-closed

10 loop servo system by forming a torque command that takes frictional resistance into consideration.

In accordance with the present invention, there is provided a numerical control apparatus of a semi-closed loop servo system for controlling a servomotor by

15 forming a position command by a move command and a backlash correction command for backlash at a mechanical load, comprising: discriminating means for discriminating, on the basis of the backlash correction command, a quadrant position prevailing when the

20 direction of rotation of the servomotor reverses; correcting means for forming a torque correction signal corresponding to frictional resistance of the mechanical load; and arithmetic means for computing a velocity command decided from the position command by

25 the torque correction signal.

Accordingly, in the numerical control apparatus of the present invention, a position command regarding the servo system and a backlash correction command are

applied to a comparator to which the servomotor
position signal is inputted, and a torque correction
signal corresponding to the frictional torque of the
machine constituting the load is applied to the servo

5 system as offset data in dependence upon the quadrant
position which prevails when the direction in which the
servomotor rotates reverses. Thus, accurate positional
control is realized by eliminating the influence of
friction with regard to the load.

10 Brief Description of the Drawings

Figs. 1(a), (b) are a block diagram and flowchart
illustrating the general arrangement of the present
invention, Fig. 2 is a block diagram illustrating an
example of a circuit according to the prior art, Fig. 3

15 is a circuit diagram of a servomotor control apparatus
using a semi-closed loop system, and Fig. 4 is a block
diagram of a servo-control system.

Best Mode for Carrying Out the Invention

An embodiment of the present invention will now be

20 described in detail with reference to the drawings.

Fig. 1(a) is a block diagram illustrating the
general arrangement of the invention. The move command
MC(i) formed by an information processing circuit and
the backlash correction command BL(i) are inputted to a

25 comparator B_1 of a servo system, and an error signal E_1
is formed by comparing these commands with the amount
of movement of a servomotor output shaft in a sampling
period T, namely the position signal POS(i). The error

signal E_1 is multiplied by the position gain K to form
a velocity command E_2, which is applied to a comparator
B_2. Also inputted to the comparator B_2 are the
servomotor velocity signal VEL(i) and a torque
correction signal FR(i) obtained from a correction
circuit A by processing the backlash correction command
BL(i) under predetermined conditions.

Fig. 1(b) is a flowchart for forming the torque
correction signal FR(i) in the correction circuit A.
Solely the backlash correction command BL(i) is input-
ted to the correction circuit A, which outputs the
torque correction signal FR(i) corresponding to fric-
tional resistance in accordance with the quadrant posi-
tion that prevails when the servomotor reverses direc-
tion. More specifically, a frictional resistance value
'a of the machine coupled to the servomotor is preset,
and the following torque correction command FR(i) is
computed in dependence upon the quadrant position,
which is discriminated by the backlash command BL(i),
prevailing when the servomotor reverses direction:

(1) $FR(i) = -Fa/(K_1 T)$

for the third quadrant [BL(i) < 0];

(2) $FR(i) = 0$

for BL(i) - 0; and

(3) $FR(i) = Fa/(K_1 T)$

for the first quadrant [BL(i) > 0].

In accordance with the correction circuit A of the
control apparatus constructed as set forth above, the

torque correction signal corresponding to frictional resistance is applied to the comparator B_2 as offset data, and a velocity command E_3 from the comparator B_2 is inputted to a comparator B_3 as a signal which

5 compensates for frictional resistance. Subsequent processing is the same as in the example of the prior-art circuit of Fig. 2, in which the command signal is corrected by the integration term z^{-1} and the gains k_1, k_2 so that a comparator B_4 may form a torque

10 command E6 for the servomotor.

In accordance with the numerical control apparatus of the present invention, as clarified by the description of this embodiment, a backlash correction regarding the move command is carried out in the

15 semi-closed loop servo system, and a torque correction can be achieved by taking the frictional resistance of the mechanical system into consideration. As a result, there is an improvement in positional displacement. based on a response delay at the time of a change in

20 the rotating direction of the servomotor.

· Though an embodiment of the present invention has been described, the invention is not limited thereto but can be modified in various ways without departing from the scope of the claims.

25 Industrial Applicability

The numerical control apparatus of the present invention can be utilized as a semi-closed loop. servo-control system adapted to effect a backlash

correction with regard to a position command.

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CLAIMS:

1. A numerical control apparatus for controlling a semi-closed loop servo-control system which controls a servomotor by forming a position command by a move

5 command and a backlash correction command for backlash at a mechanical load, comprising:

discriminating means for discriminating, on the basis of the backlash correction command, a quadrant position prevailing when the direction of rotation of

10 the servomotor reverses;

correcting means for forming a torque correction signal corresponding to frictional resistance of the mechanical load; and

arithmetic means for computing a velocity command

15 decided from said position command by the torque correction signal.

2. A numerical control apparatus according to claim 1, characterized in that said correcting means is adapted to store a frictional resistance value of the

20 mechanical load and form the torque correction signal in accordance with a predetermined offset parameter.
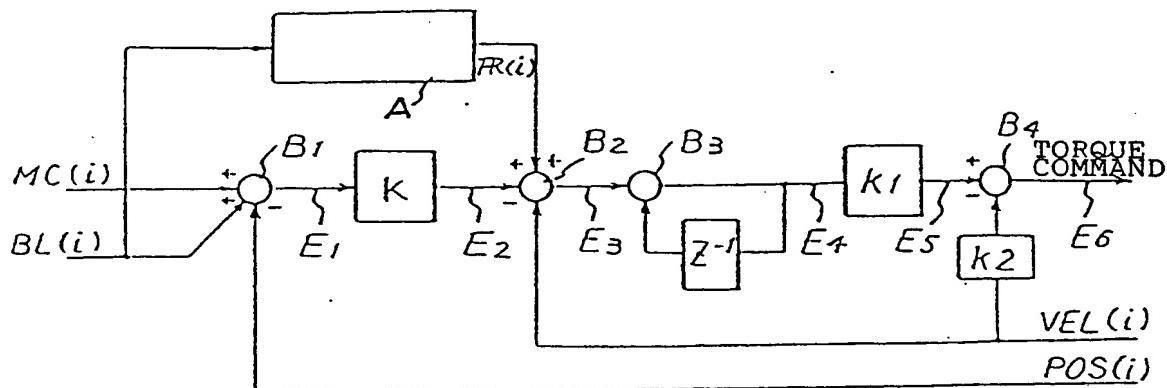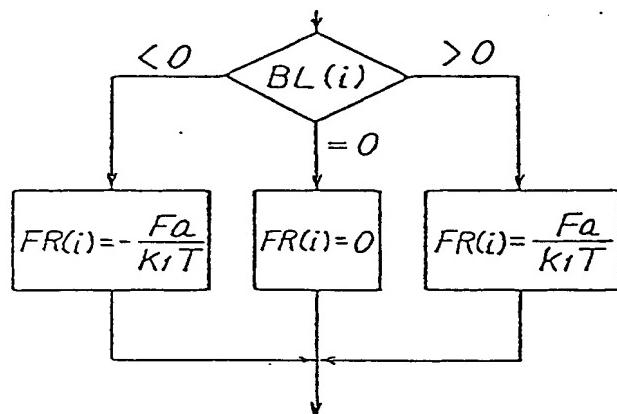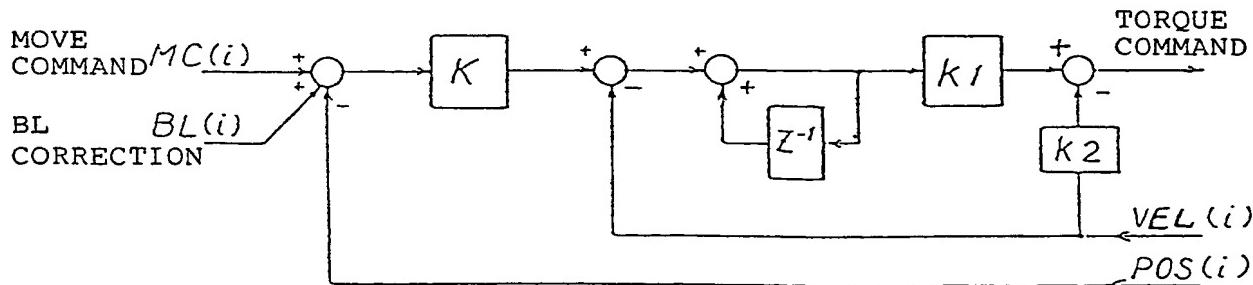
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Fig. 1 (a)

Fig. 1 (b)

Fig. 2

Fig. 3

SERVOMOTOR

Z

SERVOMECHANISM Y

COMPARATOR CIRCUIT

MACHINE

+

INFORMATION
PROCESSING
CIRCUIT

X

a   b

VELOCITY
DETECTOR

c

T

BALL SCREW f

d

R

POSITION
DETECTOR

e

SERVO DRIVE
CIRCUIT

Fig. 4

POSITION
COMMAND

TORQUE
COMMAND

T_L

K

$+$
$-$

$\dfrac{k_1}{S}$

$-$

K_T

$-$

$\dfrac{1}{J_m S}$

$\dfrac{1}{S}$

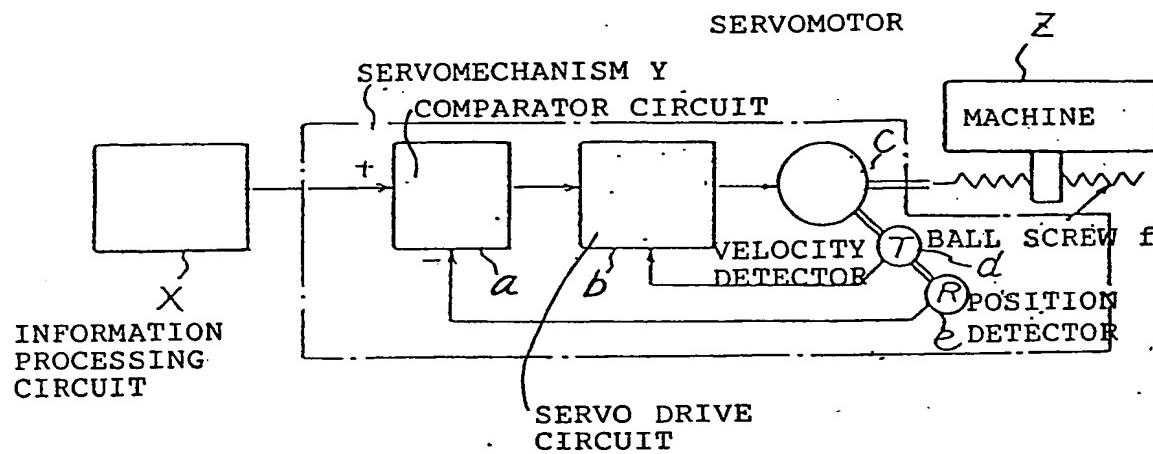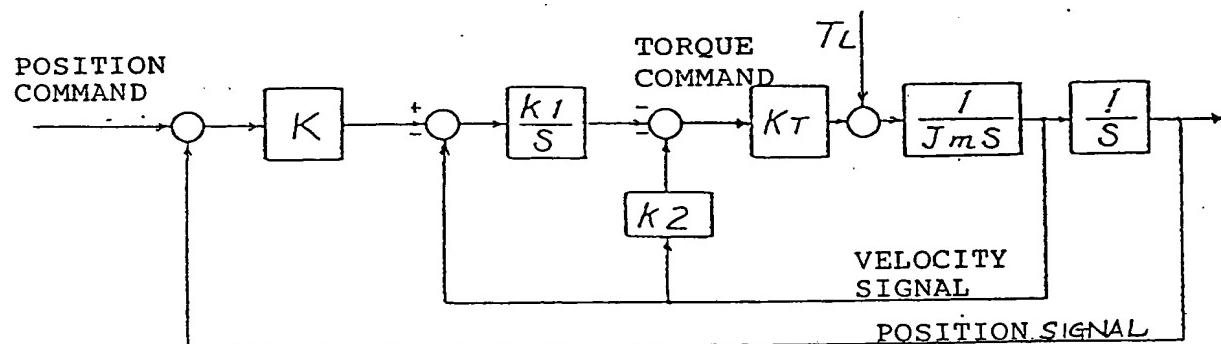k_2

VELOCITY
SIGNAL

POSITION SIGNAL

INTERNATIONAL SEARCH REPORT 00292574

International Application No **PCT/JP87/00967**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 3

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl⁴   G05D3/12

II. FIELDS SEARCHED

Minimum Documentation Searched 4

Classification System	Classification Symbols
IPC	G05D3/12, G05B19/18

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 5

Jitsuyo Shinan Koho	1971 – 1987
Kokai Jitsuyo Shinan Koho	1971 – 1987

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

Category *	Citation of Document, 16 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No. 18
A	JP, A, 60-116004 (Fanuc Ltd.) 22 June 1985 (22. 06. 85) Page 2, upper right column to page 3, upper right column, Fig. 2 (Family: none)	1-2

* Special categories of cited documents: 15

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 2	Date of Mailing of this International Search Report 2
February 23, 1988 (23.02.88)	March 14, 1988 (14.03.88)
International Searching Authority 1	Signature of Authorized Officer 20
Japanese Patent Office	

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